FRICTION

Large changes in tension can occur when a line is wrapped around a fixed cylinder.

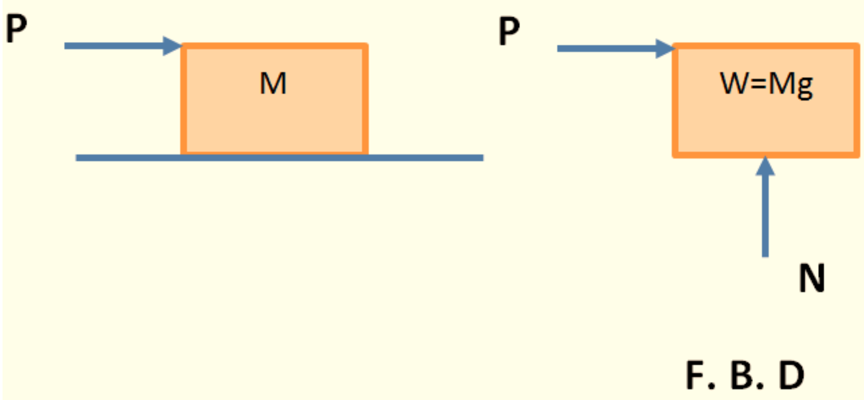
Friction 6

CHAPTER OUTLINE

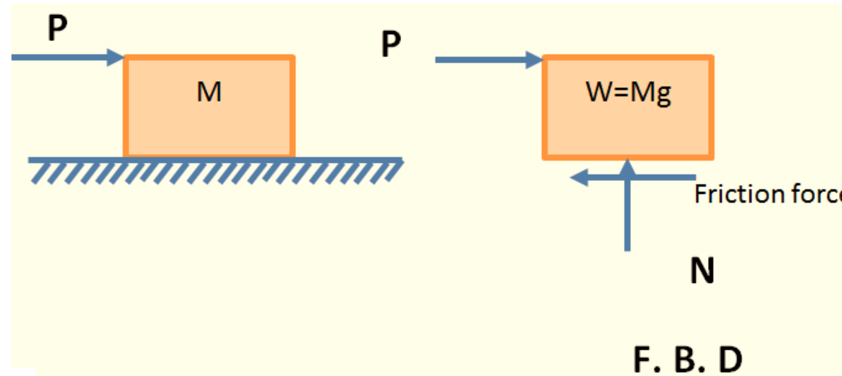
6\1 Introduction

- Tangential forces generated between contacting surfaces are called *friction forces* and occur to some degree in the interaction between all real surfaces.
- In some types of machines and processes we want to minimize the retarding effect of friction forces Examples are bearings of all types, power screws, gears, the flow of fluids in pipes, and the propulsion of aircraft and missiles through the atmosphere.
- In other situations we wish to maximize the effects of friction. Examples as in brakes, clutches, belt drives, and wedges.

FRICTION



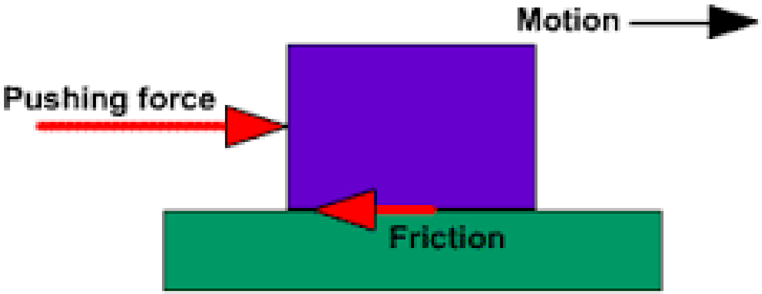
a. Smooth surface



b. Rough surface

Direction the friction force will be opposite direction of the force (P)

FRICTION



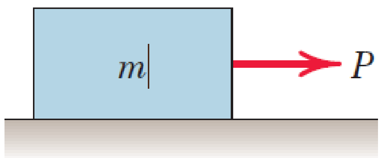
6\2 Types of Friction

- ***Dry Friction.*** Dry friction occurs when the un-lubricated surfaces of two solids are in contact under a condition of sliding or a tendency to slide.

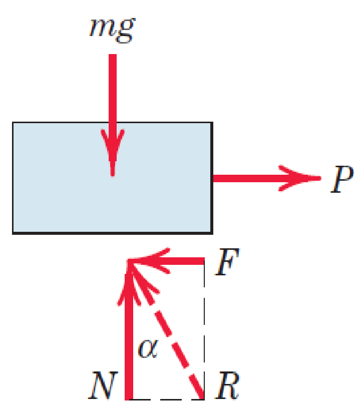
- ***Fluid Friction.*** Fluid friction occurs when adjacent layers in a fluid (liquid or gas) are moving at different velocities.

- ***Internal Friction.*** Internal friction occurs in all solid materials which are subjected to cyclical loading.

Mechanism of Dry Friction



(a)



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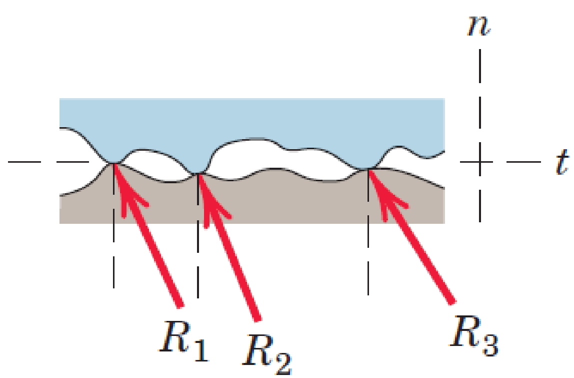
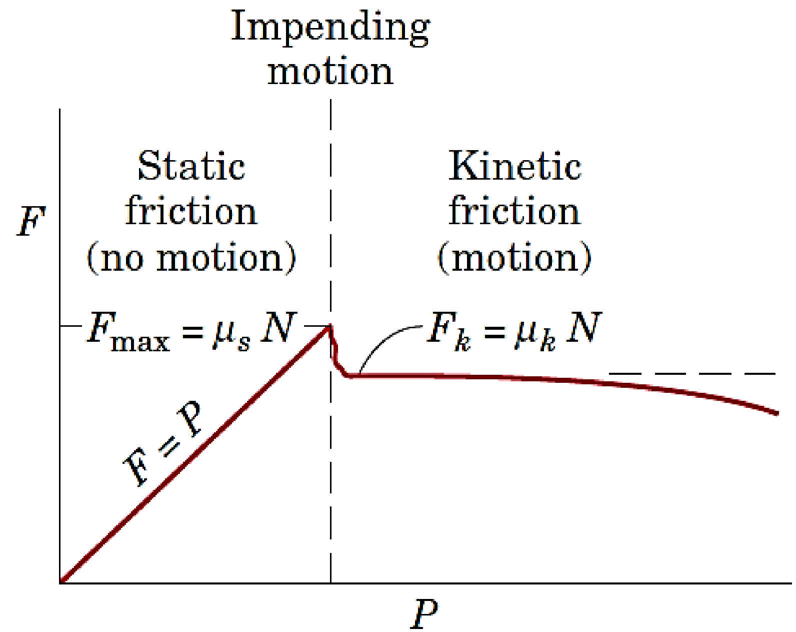


(c)

FRICTION

- The region up to the point of slippage or impending motion is called the range of ***static friction.***
- in this range the value of the friction force is determined by the ***equations of equilibrium***.
- This friction force may have any value ***from zero up to and including the maximum value.***



- After slippage occurs, a condition of ***kinetic friction*** accompanies the ensuing motion.
- ***Kinetic friction*** force is usually somewhat less than the maximum static friction force
- The kinetic friction force F_K is also proportional to the normal force

FRICTION

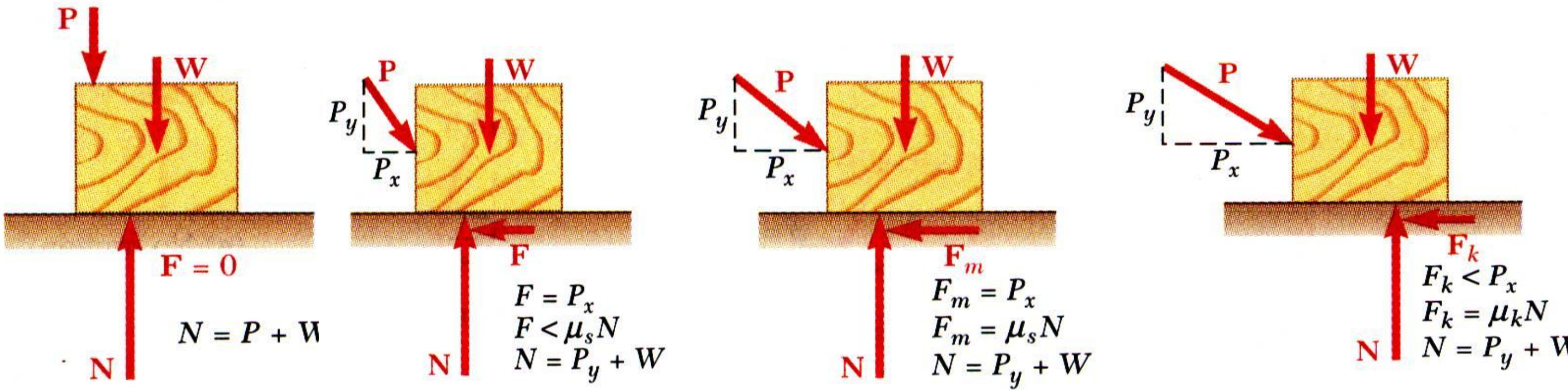
Table 8.1. Approximate Values of Coefficient of Static Friction for Dry Surfaces

Metal on metal	0.15–0.60
Metal on wood	0.20–0.60
Metal on stone	0.30–0.70
Metal on leather	0.30–0.60
Wood on wood	0.25–0.50
Wood on leather	0.25–0.50
Stone on stone	0.40–0.70
Earth on earth	0.20–1.00
Rubber on concrete	0.60–0.90

- Maximum static-friction force:
  $$F_m = \mu_s N$$
- Kinetic-friction force:
  $$F_k = \mu_k N$$
  $$\mu_k \cong 0.75\mu_s$$
- Maximum static-friction force and kinetic-friction force are:
  - ✓ proportional to normal force
  - ✓ dependent on type and condition of contact surfaces
  - ✓ independent of contact area

FRICTION

- Four situations can occur when a rigid body is in contact with a horizontal surface:



- No friction, ($P_x = 0$)
- No motion, ($P_x < F_m$)
- Motion impending, ($P_x = F_m$)
- Motion, ($P_x > F_m$)

❖ Types of problems involving frictional forces.

There are three types of friction problems which depend on the motion condition that exists

1. Impending motion is not assured from the statement of the problem.

$$\mathbf{F} < \boldsymbol{F}^{-} = \boldsymbol{\mu} * \boldsymbol{N}$$

2. Impending or relative motion is specified at all contact surfaces where there are frictional forces.

$$\mathbf{F} = \boldsymbol{F}^{-} = (\boldsymbol{\mu} * \boldsymbol{N})$$

3. Impending motion is known to exist, but either the type of impending movement (slipping or tipping) is not specified.

❖ Procedure when impending motion is not assured ((type one)):-

1. Assume the system to be in equilibrium.
2. Determine the friction and normal forces, **(F)** and **(N),** using the equilibrium equations.

$$\sum f_{x=0}\ ,\qquad \sum f_{x=0}\ ,\qquad \sum M_{at\ any\ point\ =0}$$

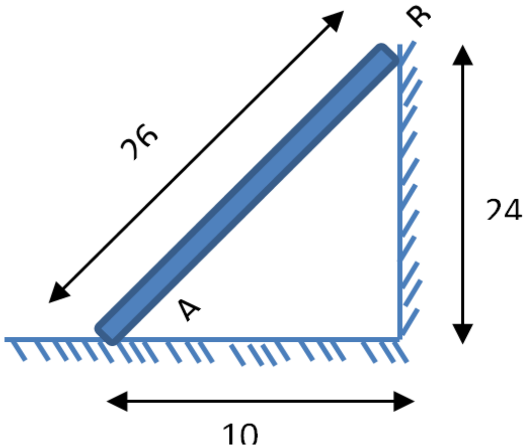
$$\sum f_{x=0}\ ,\qquad \sum f_{x=0}\ ,\qquad \sum M_{at\ any\ point\ =0}$$

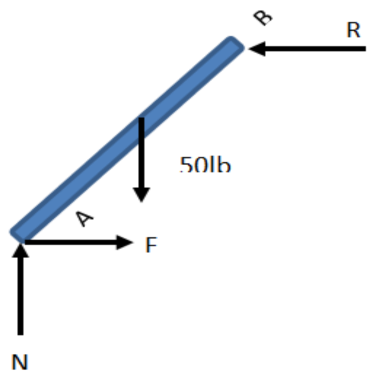
3. Check the initial assumption by comparing **(F)** with $F^{-} = \mu . N$

If **F** $\leq F^{-}(\mu N)$, the assumption is correct and the problem is solved.
If **F** $> F^{-}(\mu N)$, equilibrium is does not exist, and a complete solution involves the principle of dynamics.

Ex:- 26 ft. ladder weights **50 lb**. and it is placed against smooth vertical wall with its lower end **10 ft**. from the wall. The coefficient of friction between the ladder and the floor is **0.3**. Determine the friction force at acting on the ladder. The mass center of the ladder is assumed to be at its mid-point.

Solution:-





FRICTION

❖ **procedures when impending or relative motion is specified at all contact surfaces will frictional forces ((type two))**

1. Write the equation of friction.

F= $F^{-} = (\mu * N)$, for all surfaces where motion impends.
(make sure that the sense of the friction force is correct), the friction force opposes the motion or the tendency to move.

2. Determine the unknown quantities, using the equation of equilibrium together with the friction equation:-

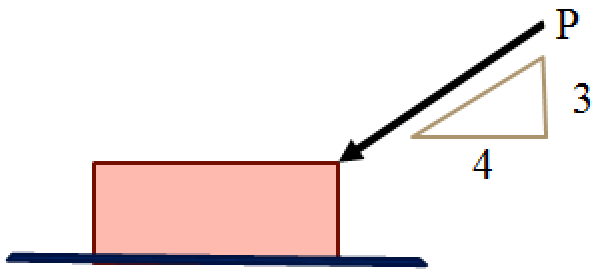
$$F^{-} = \mu * N$$

No check is necessary for this type of problems because no assumptions are required.

FRICTION

Ex:- if **p = 200 N**. Determine the friction developed between the **50 kg** carte and the ground. The coefficient of static friction between the crate and the ground is $\mu = 0.3$

Solution:-



$\uparrow \sum F_y = 0$

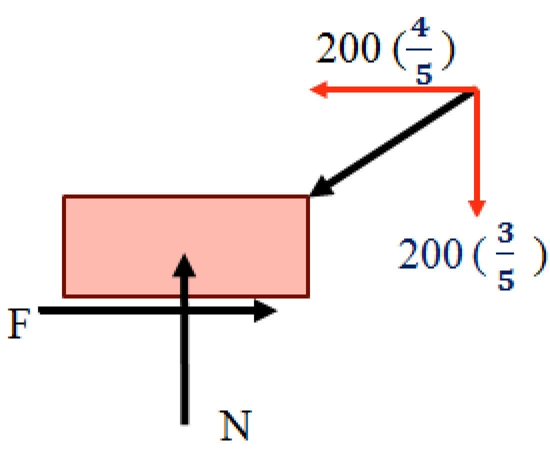
N – 200 ($\frac{3}{5}$) – 50 (9.81)

N = 610.5 lb.

$\rightarrow \sum F_x = 0$

F – 200 ($\frac{4}{5}$) = 0

F = 160 lb.



$F_{max} = \mu \, . \, N = 0.3 * 610.5 = 183.15\ N$

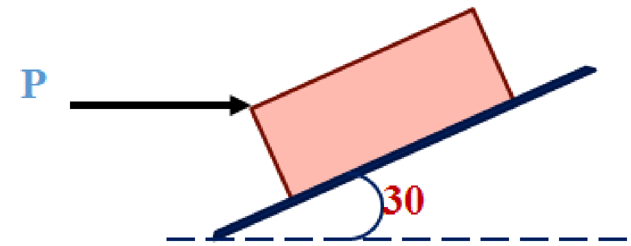
F = 160 $< F_{max} = 183.15\ N$

There for F = 160N

FRICTION

Ex:- Determine the minimum **P** required to push the crate up the plane. The crate has a mass of **50-kg** and the coefficient of static friction between the crate and the plane is **μ = 0.3.**

solution:-



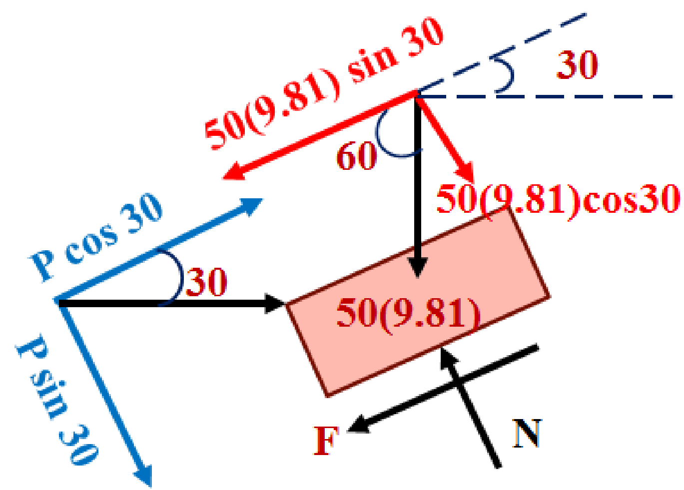
The body in impending motion

$F = F_{max} = \mu . N = 0.25\ N \ , \quad F = 0.25\ N$

$\sum F_y = 0 ,$ N - 50(9.81) cos 30 - P sin 30 = 0 ……1

$\sum F_x = 0 ,$ - F - 50(9.81) sin 30 + P cos 30 = 0 ……2

- $0.25\ N$ - 50(9.81) sin 30 + P cos 30 = 0 ……3



From 1 and 3, we found

P = 474 N
N = 661.92 N